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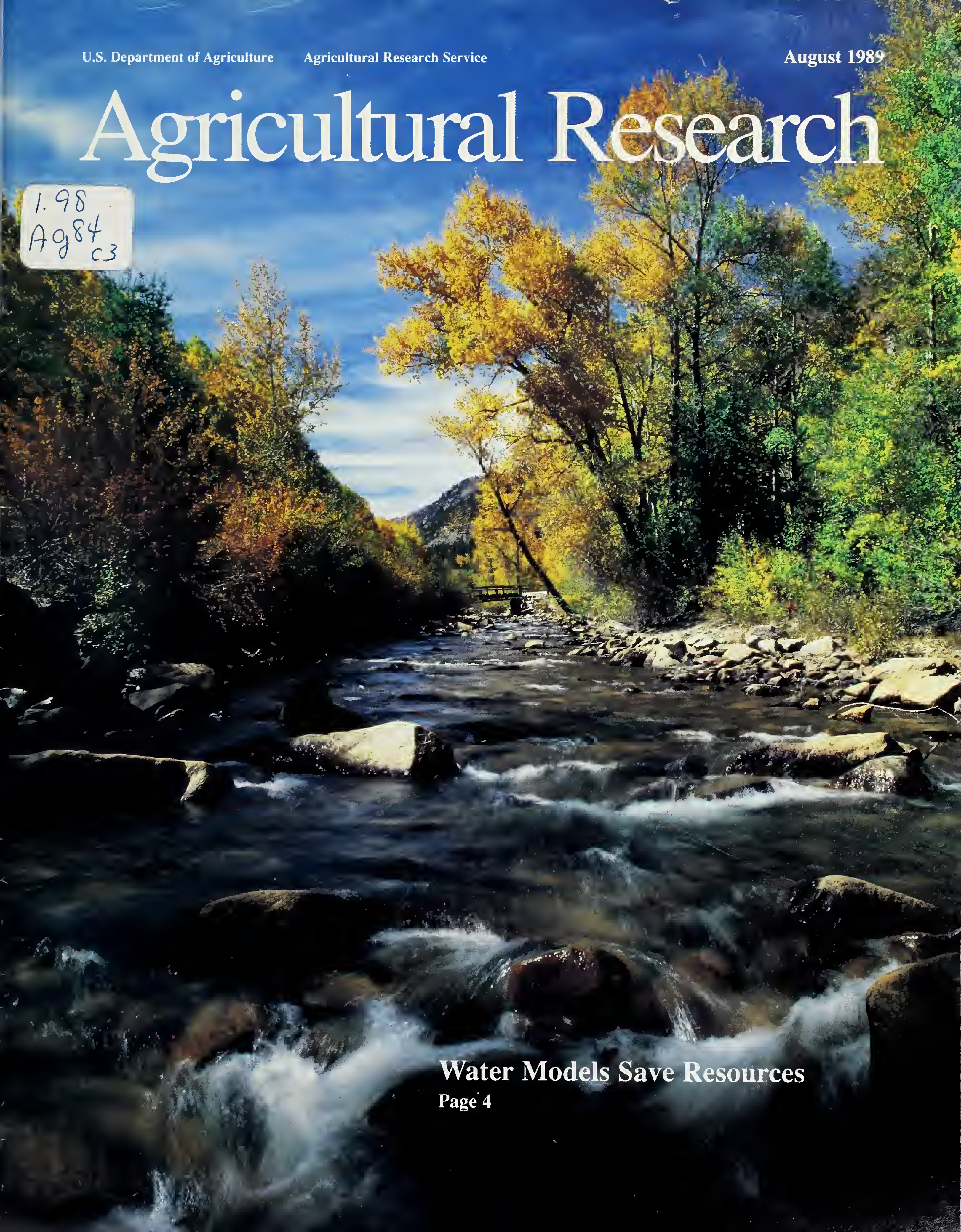
Agricultural Research



Water Models Save Resources
Page 4

Computer Models Aid Groundwater Protection

Today, roughly 330,000 tons of pesticides are applied yearly on U.S. crops. With such use arises the potential for some pesticides to move downward from application sites into the groundwater.

To help safeguard U.S. groundwater, a water supply on which some 127 million people depend, the Agricultural Research Service has laid down a specific strategy.

The ultimate goal of our plan is threefold: (1) To provide the American farmer with cost-effective best management practices that continue to assure the public ample supplies of food and fiber at reasonable cost while reducing pesticide movement into groundwater, (2) To identify the factors that accelerate or retard pesticide movement, and (3) To provide computer models that will quickly and accurately predict those circumstances leading to groundwater contamination.

We are concentrating on six areas of research:

- Conservation tillage practices
- Integrated pest management
- Improved pesticide application technology
- Improved water/pesticide management practices
- New methods of pesticide analysis and decontamination
- Improved computer models

In this issue of *Agricultural Research,* the cover story explores the final item on the agenda, computer model applications [See *Water Models Save Resources*, p. 4].

These are decision-enhancing tools that, by extrapolating from an available database, can provide farmers with a selection of management practices. Models integrate data from many sources to provide useful information to farmers and are thus an important tool for technology transfer.

Computer models are being used to identify the more sensitive pesticide processes related to movement. They are also helping our scientists determine the best management practices for minimizing pesticide leaching to groundwater in a variety of soils, climates, and other environmental conditions.

Not only are we working to make these tools more effective and more precise, but scientists are extending existing models to more fully account for factors that increase or decrease pesticide mobility and persistence.

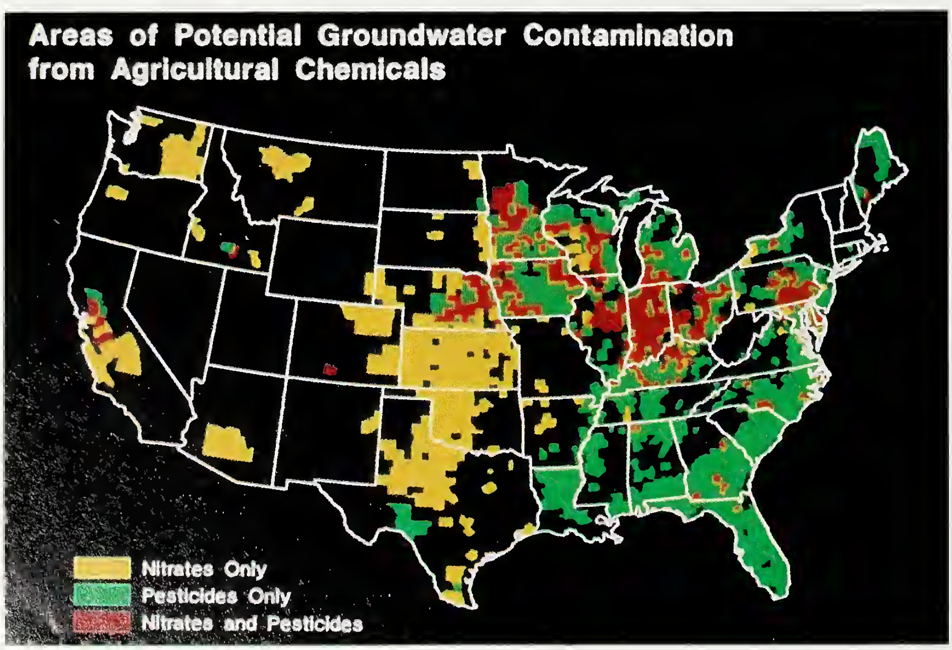
Researchers at six locations are documenting, testing, and evaluating the limitations of current field-scale models.

We're expanding the physiochemical databases of pesticides to develop management systems that will reduce the potential for groundwater contamination.

And we're constantly improving our existing models to assist in selection, evaluation, and implementation of new technologies and practices to limit pesticide leaching while still achieving the pest control necessary for economically viable farming. These new technologies include such advances as slow-release formulations, improved pesticide application scheduling, and selective placement.

Thanks in part to progress made in computer modeling, the prognosis for improvement in tomorrow's groundwater is good. But ARS scientists clearly have their work cut out for them. Today, groundwater contamination by agricultural chemicals is considered a risk in many of the major crop and livestock producing areas of the country (see below).

David A. Farrell
ARS National Program Leader, Water Quality
Beltsville, Maryland



Source: Elizabeth G. Neilsen and Linda K. Lee, 1987. The magnitude and costs of groundwater contamination from agricultural chemicals: A national perspective. U.S. Department of Agriculture, Economic Research Service, AER 576.

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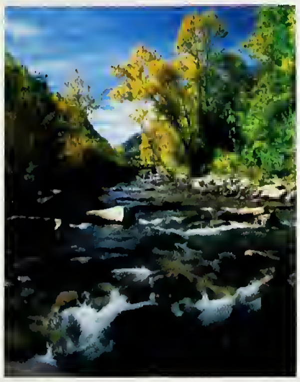

The lifeblood of agriculture, pure water courses through a Colorado stream.
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DEPARTMENTS

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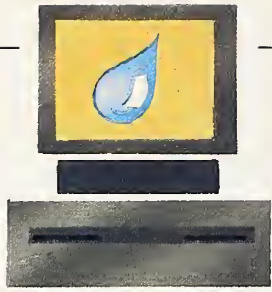
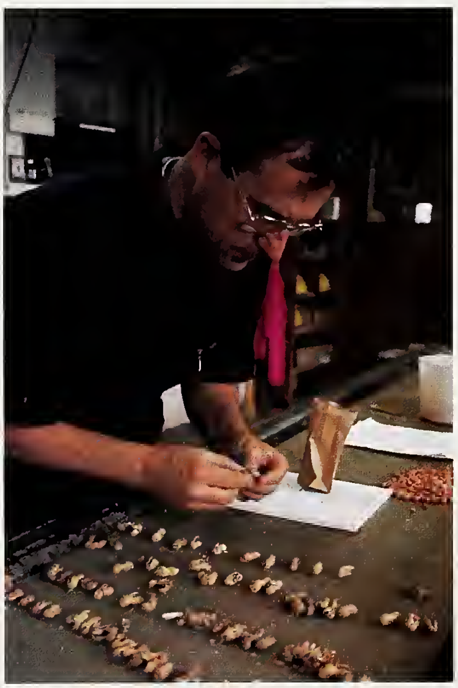


Water Models Save Resources

DAVID NANCE

Top: **Wesley Rosenthal (kneeling) and John Fox of the Texas Agricultural Experiment Station at Temple, Texas, measuring the light intercepted by cotton plants. The data will be used in computer models. (K-3226-6)**

Right: **Mechanical engineer James Davidson evaluates peanuts from last year's tests to confirm the ability of the Peanut Expert System to provide recommendations for growing a high-quality crop. (K-3219-10)**



ROB FLYNN

Henry Haddock sat in front of a personal computer at his Damascus, Georgia, peanut farm, touched a few keys, and found out when to irrigate and spray a fungicide on his peanut crop.

With the aid of a computer program known as the Peanut Expert System, much of the guesswork in irrigating peanuts can be eliminated, says James I. Davidson of USDA's Agricultural Research Service. Davidson is co-developer of the software.

Haddock was one of eight farmers last year who agreed to test the new system. He used it on 100 acres of the 400 acres of peanuts on the farm in southwest Georgia. He and his brother Hal have been working this farm since 1969.

Says Davidson, a mechanical engineer at the National Peanut Research Laboratory in Dawson, Georgia, "The computer helps the farmer make production decisions based on research findings rather than on a farmer's feelings. We're really pleased with the way it has worked."

Davidson and research technician Ron Williams are continuing to work with the Extension Service and farmers to test the software and find ways to expand its usefulness to the farmer.

Davidson says the system's results must be further validated before it becomes widely accepted, but farmers could have some of the technology in hand by next year. Scientific manuscripts are being prepared to describe some of the new concepts in the program.

Some of the benefits expected are a reduction in the amount of chemicals applied to control peanut pests and in diseases that normally occur

when a field is overirrigated. Using fewer chemicals should reduce chemical leaching into groundwater, Davidson says.

Steve Singletary, a peanut farmer in Blakeley, Georgia, agrees that proper irrigation should reduce disease. Singletary tried the system on about one-fourth of his 800-acres of peanuts in 1987 and 1988. While he has applied about the same amount of chemicals with both conventional farming methods and the expert system, Singletary is convinced irrigation costs will decrease.

For example, last year he reduced irrigation by 1 to 1-1/2 inches by

"The computer helps the farmer make production decisions based upon research findings rather than on a farmer's feelings. We're really pleased with the way it has worked."

James I. Davidson, Mechanical Engineer
Dawson, Georgia

using the system. Irrigation costs were about $10 per acre less.

Haddock says his peanut fields received abundant rainfall last year, so differences in his yields under the conventional method compared with the software program weren't noticeable.

In general, Davidson says, a third to half of the 20-25 inches of water needed to produce a peanut crop comes from irrigation. The program should cut total water use to 16 to 20 inches per crop-year.


DAVID NANCE

Agricultural engineer John Morrison photographs soil surface covered by crop residue. Information from the photos is used in EPIC tillage simulations. (K-3224-1)

"It gives you a lot of other benefits," he says. "The average grower should see yields increase by 300 to 400 pounds per acre a year." In addition, a higher quality crop could improve profits by about $30 per ton.

At the same time, the program should reduce chemical use by 10 to 30 percent. The system should eliminate at least two applications of pesticides per year.

Following the program's recommendations should make it easier to get a crop even during a drought because what water is available will be applied at the right time, Davidson says.

When testing of the program began 3 years ago, four peanut farmers participated in the experiment. Last year, eight growers in both Georgia and Alabama, all experienced farmers, compared the recommendations of the expert system with those based on their own judgment.

On the average, irrigating according to the system provided 100 pounds per acre more yield and better quality peanuts than irrigating based solely on experience.

Davidson says the computer is 80 to 90 percent accurate in timing irrigations compared with an accuracy rate of about 50 to 70 percent with conventional farming.

His work actually stems from an inquiry in 1980 from the Georgia Extension Service, which was looking for a better way to control pests and to irrigate peanuts.

The Dawson lab gathered research data and information on current peanut farming methods. ARS researchers also used input from local

farmers on traditional peanut farming practices.

In cooperation with the Extension Service and the Georgia Agricultural Commodity Commission for Peanuts, work on the Peanut Expert System began in January 1985, when the Dawson lab enlisted the help of a related ARS lab—the Grassland Soil and Water Research Laboratory in Temple, Texas—to help write the program.

Field name, soil type, yield potential, irrigation capacity, date of planting, amounts and dates of rainfall and irrigation, soil temperature, and canopy coverage were all programmed as questions for the farmer to answer.

Once the farmer answers those questions, the software suggests when and how much irrigation is needed. It also provides information on what pest or soil problems to evaluate, how often to apply fungicide to control leafspot—the most common peanut disease—and when to check the field and update the information.

"The next time you want to use it, you just update the information," Davidson says.

The program is not limited to one particular type of soil. It can offer advice to peanut farmers whose fields are predominantly sandy as well as those with heavier soil.

"We will continue to validate and improve the system," Davidson says.

ARS' Temple, Texas, lab is also home to EPIC, the Erosion Productivity Impact Calculator. This computer model helps estimate future soil erosion and fertilizer losses that could muddy water supplies.

DAVID NANCE

SCS agricultural economist Verel Benson (standing) and Dan Taylor (seated, facing students) conduct a workshop on the use of EPIC and SWRRB. (K3227-10)

EPIC users have projected as far as 1,000 years into the future based on past weather data and current information about farming practices.

"EPIC simulates the natural processes out on the land," explains Jimmy R. Williams, a hydraulic engineer at the Temple lab. "The model will tell you what will happen for as many years as you specify: what your annual crop yields will be, how much runoff you'll have, how much erosion, how much nitrogen fertilizer will be lost because of percolation through the soil, and what the status of your soil and water is for any time of the year."

EPIC is used extensively by USDA's Soil Conservation Service, universities, and many researchers.

EPIC's users also include INRA, a research organization based in Toulouse, France, and individuals in West Germany.

"INRA is currently taking measurements in the field, running the model, and comparing the results," Williams notes. "So they're both evaluating the model and using it to make predictions.

"They have plans to make it available to French farmers or agricultural managers at some level. They've been working with EPIC since 1984."

Although EPIC can handle complicated tasks, using it is fairly simple, according to Williams.

"We compiled weather station records from all over the United States and built them into the system," he explains. "We also have a big database on different soil types, so users of the model first specify what type of soil they're dealing with.

"Farmers need to know what farm management will be used. They type in some sort of plan—"I'll plant my crop in April, go no-till, and harvest in September, for example—and EPIC gives them the answers. You get a lot of averages on possible yields, water runoff, and erosion to show you what to expect, month by month, over the long term."

EPIC is not yet being used by individual farmers in the United States, Williams says, but a few farm management consulting firms have contacted the Temple lab about the model.

"We sent one firm a package that included the model and a users' guide," he says.

"EPIC runs on a personal computer, and there are farmers around the country who are computer-oriented enough that they wouldn't have any problem using it.

"Also, it could go to Extension Service offices where county agents might help farmers use it; it would fit very well in that type of situation."

Before EPIC, formulas devised by USDA's Economic Research Service were used to calculate the impact of soil erosion and weather on crop yields and the land. Aside from those formulas, "there wasn't really anything but subjective estimates, bits and pieces of field data where someone had done a study for 3 years or 5 years," says Williams.

A December 1980 meeting of representatives from several federal agencies on the situation led to the formation of a 14-member team to put together a computer model that could mimic "what happens every day in nature," Williams says. The team included members from across the nation, but work on the model that became EPIC centered at the Temple lab.

Also at Temple, work is already underway on a more detailed model called ALMANAC that will require more farm management details from the user, but can offer predictions for more complex farming situations such as growing two crops at once. ALMANAC is an acronym for Agricultural Land Management Alternatives With Numerical Assessment Criteria.

ROB FLYNN

Collecting data for the Peanut Expert System, engineer James Davidson (left) makes a field entry in his notes as participating grower Don Sparks (center) watches ARS engineering technician Tommy Bennett take a soil sample on Sparks' farm. (K3218-1)

ROB FLYNN

ARS engineering technician Ron Williams (left) reviews soil temperature and rainfall data with participating grower, Henry Haddock. (K-3215-8)

"Internationally, farmers do a lot of intercropping," says Williams. "One way this is done here in the United States is with clover and wheat. The wheat matures earlier and can be harvested. Then the clover comes up and can be baled for hay or turned under to enrich the soil."

But perhaps the biggest selling point of ALMANAC is its ability to account for the impact of weeds on the crop, affecting herbicide use among other farm management considerations, Williams adds.

"Weeds are a critical factor in conservation tillage," he notes. "You have to control weeds, either by tillage or use of herbicides."

While ALMANAC is still probably 2 to 3 years away from completion, another important outgrowth of EPIC is already in operation. It's a leaching index that allows farmers to estimate how likely nitrate from nitrogen fertilizer is to be carried downward in their soils by water. Such leaching can open the door to contamination of underground water supplies.

"In the summer of 1987, we used EPIC to simulate nitrate leaching in about 15 locations around the United States," Williams recalls.

"We picked four soils that represent different hydrologic groups of soils, from very permeable to impermeable, and we did 20-year simulations. We averaged annual water percolation, figuring in wet years, dry years, and in between."

For farmers to use the leaching index, they would need to know the type of soil on the farm, the annual rainfall for the area, and how much of that rainfall occurred in the non-growing season.

During the growing season, crops use much of the available water, so there is less likelihood of rainfall percolating down through the soil, carrying nitrate with it.

DAVID NANCE

At "rain out" shelters used to simulate drought conditions, research agronomist James Kiniry (foreground) and biological aide Donald Elliot conduct an experiment with corn, sorghum, and sunflowers to gather information for computer plant growth models for the ALMANAC program. (K-3222-1)

Soil type is an important factor in the calculations. On very sandy soils, percolation can be significant even in the early days of the growing season, Williams says.

As an example, he cites calculations on a Houston black clay soil and a Silawa sandy loam, each with a water content of slightly less than field capacity the day before a 3-inch rain.

On the sandy loam soil without a crop, 1.14 inches of the 3 inches of rain percolated through the soil, mostly within the first 2 days after the rain. Refiguring the example to include the presence of a wheat crop on the land reduced percolation to 0.89 inch.

On the clay soil without a crop, percolation continued longer but still totaled only 0.76 inch, less than percolation on the sandy soil with a crop. With a wheat crop on the clay soil, only 0.25 inch of rainfall would percolate, according to Williams' calculations.

"If farmers use the leaching index and come up with a big number, they will know they have to manage their fertilizer well or lose a lot of it to percolation," says Williams. "Then they could use EPIC to find out when and how much fertilizer to apply, and whether to apply it all at once or not."

Williams also played an important part in the development of SWRRB, the Simulator for Water Resources in

Rural Basins, which can do calculations on areas up to several hundred square miles.

Williams and Arlin D. Nicks, a hydraulic engineer at ARS' Soil and Water Resources Research unit at Durant, Oklahoma, developed the framework for SWRRB in the early 1980's, according to Jeffrey G. Arnold, a hydraulic engineer at the Temple lab.

"With SWRRB, you can look at several field-size areas individually, do the calculations, and hypothetically route outputs such as sediment or fertilizer to a water basin," Arnold explains. "You can look at your upland fields and see how the things you do there will affect reservoirs, rivers, or whatever."

To use SWRRB, the user must know the area's daily rainfall, temperature, and solar radiation, although SWRRB does have a built-in database of weather records that helps eliminate guesswork.

The user also needs information on the soils in the area and topographical factors such as slope and land use—whether the area is rangeland, forest, or cropland, and the type of crops being grown.

"Each run on SWRRB will give you how much water left each subarea, how much sediment, how much nitrogen, phosphorus, and pesticide," says Arnold. "It also figures out how much of these substances actually makes it to the reservoir or river or whatever you're studying.

"These subareas can be 10 to 20 square miles apiece. We've tested areas up to 300 square miles with SWRRB, and we're working on a project now that involves modifying the system to look at 10,000 square miles."

"With SWRRB, you can look at several field-size areas individually, do the calculations, and hypothetically route outputs such as sediment or fertilizer to a water basin. You can look at your upland fields and see how the things you do there will affect reservoirs, rivers, or whatever."

Jeffrey G. Arnold, hydraulic engineer
Temple, Texas

That project involves an engineering group, just one of the many and varied users of SWRRB. The group is involved in a water rights dispute in Arizona and is calculating, for example, water yields on specific areas and how those yields might be altered by the actions of various entities, such as cities.

"The Environmental Protection Agency has a version of SWRRB as a pesticide assessment model," Arnold notes. "If a chemical company has a new pesticide they want to sell, EPA uses SWRRB to calculate the pesticide's mobility, how much of it would go to runoff, and how much would attach to sediment. The chemical companies also have a version of SWRRB to test these things before they turn the chemical over to EPA."

Other users include the National Oceanographic and Atmospheric Administration, USDA's Soil Conservation Service, and the University of Oklahoma.

"The university has a contract with the National Aeronautical and Space Administration (NASA) to use SWRRB to validate information from some of the satellite images NASA is obtaining regarding the Earth's moisture," Arnold explains.

The Temple lab does not actually do the computer runs for SWRRB users, but instead sends them a user's manual, computer disks, and other necessary items to make the model work.

"Then if they have questions, they just call," Arnold says. "We don't do the work, but we try to help them with their problems whenever we can.

"Water quality is a hot issue right now," he continues. "SWRRB is one of the better tools we have on the basin level to assess what's happening with our water resources. With the weather generator and this, it's easy to look at a lot of scenarios."—By **Bruce Kinzel** and **Sandy Miller Hays,** ARS.

James I. Davidson, Jr., is in the USDA-ARS National Peanut Research Laboratory, 1011 Forrester Dr. SE, Dawson, GA 31742 (912) 995-4481. Jimmy R. Williams and Jeffrey G. Arnold are in the USDA-ARS Grassland, Soil, and Water Research Laboratory, 808 East Blackland Rd., Temple, TX 76502 (817) 770-6500. ◆

Weather Wizard

Armed with a personal computer and an easy-to-use program called Weather Wizard, Pacific Northwest ranchers, farmers, and researchers are now better able to plan for tomorrow's weather.

Farmers and ranchers are well aware that keeping long-term weather records is tedious, timeconsuming, but necessary.

"Planning when it will be dry enough to bale hay or deciding the best time to seed, fertilize, or irrigate are based on weather data. These records can be obtained from weather stations but may not fit local conditions or may be cumbersome to use," says ARS hydrologist John F. Zuzel. So he and co-workers in Pendleton, Oregon, developed Weather Wizard.

"Our new computer program lets farmers and ranchers fine-tune weather records to planting, growing, and harvesting needs on their own farms," he says.

"We've incorporated 30 years of specific weather data from 19 National Weather Service stations into Weather Wizard," he says.

"For locations other than weather stations, the program interpolates information from the four nearest stations," says Zuzel. "That means you can predict the average weather several weeks in advance for any farm or field in a nine-county wheat-producing region east of the Cascades in north-central Oregon."

Weather Wizard provides possible weather sequences, including daily rainfall, temperature, and solar radiation, from 10 days to a year in advance.

The program will be useful to growers, ranchers, researchers, extension agents, Soil Conservation Service (SCS) technicians, and others who depend on accurate weather data.

SCS conservationists are already using it to predict maximum daily rainfall, which will help them design drainage and irrigation structures to contain or divert runoff resulting from spring snowmelt.

Weather Wizard was developed in cooperation with the Oregon State University Extension Service. Floppy disks can be obtained from the Extension Service in Corvallis (address below).

Extension specialist Russell S. Karow, who is helping distribute the program, says it's very useful for scientists to forecast the movement of various pesticides through the soil under average versus extreme weather conditions.

But for short-term weather predictions, Karow recommends using daily reports and current weather projections rather than the computer.

According to Zuzel, the software can be tailored to fit other U.S. locations. A similar Weather Wizard program covering southeastern Washington has just been completed. It should be available later this year from the Washington State University Cooperative Extension Service in Pullman.

And in South Dakota, ranchers and farmers are already using a comparable program called CLIMATE to help them decide when to plant, irrigate, spray pesticide, or harvest their crops.

David A. Woolhiser, an ARS hydraulic engineer in Tucson, Arizona, developed the CLIMATE program.—By **Howard Sherman,** ARS.

John F. Zuzel is in USDA-ARS Soil and Water Conservation Research, Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97801 (503) 276-3811. David A. Woolhiser is at the USDA-ARS Aridland Watershed Management Research Laboratory, Tucson, AZ 85719 (602) 629-6381. Russell S. Karow is with the Oregon State University Extension Service, Corvallis, OR 97331 (503) 754-2771. ◆

Pinpointing Pollutants with Soil Samples

Supercritical fluid extraction (SCF) may be the method of testing groundwater quality in the next decade.

Scientists have put this sophisticated technology to work, checking for contaminants beneath an animal slaughter and waste compound in Beardstown, Illinois. It's a site where contaminants may already have leached into the water table.

Jerry W. King, an ARS chemist, says samples taken from holes drilled below the site and from locations upstream and downstream of the compound were suspected of containing elevated levels of organic compounds, such as animal and processing wastes. All samples were shipped to the agency's Northern Regional Research Center in Peoria, Illinois, for SCF analysis.

Supercritical fluids are highly compressed gases, such as carbon dioxide, with densities that resemble—but never become—those of liquids. Instead, the gases are held in an intermediate state between liquid and gas.

In an extraction chamber, the fluid flows through a sample and dissolves specific chemicals. The gas is then decompressed and harmlessly vented to the atmosphere, leaving the extracted chemicals behind.

With the Beardstown soil samples, the process is different in one aspect. The chemical components in the soil are leached out and trapped by freezing, then swept into a chromatograph for analysis.

While results are not yet in, the work provides an opportunity to test the feasibility of using SCF technology to extract and examine contaminants in the soil, research seldom done before.

Chemist Jerry King prepares a soil sample for insertion into a supercritical fluid extractor/chromatograph. (K 3198-5)

The technology can currently remove organic compounds that conventional extraction processes, using liquid solvents, are unable to.

That, says King, saves analysis time and solvent disposal costs, while eliminating the risk of exposure to harmful liquid chemical solvents.

"But that's not all," he says. "The real superiority of this technology to liquid chemical extraction is that supercritical fluids are able to penetrate the soil more effectively and actually find organic compounds traditional solvents have missed."

The work is a cooperative effort between ARS scientists and Michael Caughey and Michael Barcelona of the Aquatic Chemistry Section of the Illinois Water Survey. State officials are hoping SCF technology will prove a more efficient and safer method for extracting and testing water and soil samples.

"Interestingly, a number of research groups have demonstrated that supercritical fluid extraction is applicable to cleaning up soils and waste streams," he says. "Our studies may allow a quick assessment on the feasibility of applying engineering-scaled processes for that purpose."

King says the next step in the process will be integrating a mass spectrometer into the research, a move that will expand the capability of the technology to monitor water and soil quality.

"Right now, we have complex chromatographic profiles containing many unknown components," King says. "When we add a mass spectrometer, this will give us a breakdown of the molecular structures of these compounds and allow us to assess the risk of contamination, if any, that these compounds pose to the environment."—By **Matt Bosisio,** ARS.

Jerry W. King is in USDA-ARS Food Physical Chemistry Research, Northern Regional Research Center, 1815 North University St., Peoria, IL 61604 (309) 685-4011. ◆

Guard Dogs Mean Business

A large, white, shaggy dog is out for a late-night walk. But it's not the usual canine stroll down city streets or across suburban backyards. Zeus is on coyote patrol.

This Great Pyrenees dog guards the 2,500 sheep on Dee Blanchard and sons' 480-acre ranch near Chester, Idaho. In summer, he follows Blanchard's sheep up the slopes of the Targhee National Forest as they graze the mountain pastures.

What Zeus and other dogs, male and female, are doing—humanely and cheaply protecting sheep, goats, and cattle from attack by coyotes, bears, and wild dogs—has now been documented in a survey of U.S. sheep ranchers.

To find out just how practical guard dogs are, wildlife biologist Jeffrey Green and coworkers in the Agricultural Research Service conducted the largest U.S. survey of independent owners of guard dogs to find out who was actually using the animals and how well they protected sheep.

Of the 1,000 questionnaires mailed, 399 responses were received, reporting on 763 dogs from almost every state in the country. The greatest number of responses came from Texas, California, Washington, Oregon, and North Dakota.

"Our survey shows that ranchers' attitudes about the dogs have changed over the last 10 years," says Green who is based at the U.S. Sheep Experiment Station in Dubois, Idaho.

"Back then they were considered a novelty," he says. "Today, much of the skepticism is gone. Guard dogs have proven their ability to protect livestock. It's been a timely development, since several states have restricted the use of other predator control techniques, such as hunting coyotes from a plane or trapping or poisoning them."

U.S. guard dogs have their work cut out for them. In Idaho alone, an estimated 23,400 sheep valued at $1.76 million were killed by predators in 1986.

"More than 80 percent of the ranchers surveyed indicated that the dogs saved sheep and were worth their initial cost of about $500, plus the dollar or two a day it takes to maintain them," he says.

"Green's guard dog program has been an unqualified success," says Hudson Glimp, director of the U.S. Sheep Experiment Station. "At the time he started it, sheep ranchers desperately needed a nonlethal means of controlling sheep predation. He showed that dogs work."

Until recently, Green worked for the Agricultural Research Service.

LOWELL GEORGIA

Rufus, a Great Pyrenees, guards his sheep from the photographer at the Brent Knight ranch near Hamer, Idaho. (K-3019-8)

LOWELL GEORGIA

Guard dog with a flock near Dubois, Idaho. (88BW2057-27)

Now that he has proven the dogs' ability protect sheep, he and his program have been transferred to the Animal Damage Control unit of USDA's Animal and Plant Health Inspection Service. However, he will continue to be based at the Dubois station.

Green is currently working on a script for a video on training dogs and expects to spend the next few years talking to western ranchers and farmers about the advantages of using guard dogs. He'll also help livestock producers find and train them.

Why Sheep Need Guards

Over the centuries, sheep were bred for their tameness and inclination to follow each other as they were herded from one mountainside to another. Unfortunately, their lack of aggressiveness presented a problem: Sheep became "sitting ducks" for predators like coyotes.

Gradually, certain breeds of dogs—like Great Pyrenees, Komondor, Akbash, and Anatolians—began to be valued for their ability to guard livestock, but only during the past 10

years has interest in guard dogs been aroused in this country.

"Since 1978, we've placed about 160 dogs with ranchers in Idaho, Wyoming, Oregon, and Washington to learn how well the dogs do under field conditions," says Green. "We purchased most of our dogs from commercial breeders.

"The ranchers keep us informed on how well the dogs are doing," he says. "Ordinarily, I don't see the animals again unless it's to help work out a problem."

According to Green's survey, no particular breed or sex was rated better than others, except that Komondors injured sheep and bit people more often than did Pyrenees.

The U.S. Sheep Station is not the only place guard dogs are studied. Since 1977, Ray Coppinger and his staff at the New England Farm Center at Hampshire College in Amherst, Massachusetts, have raised and placed about 1,100 dogs in 37 states.

"Not all of these animals are working guard dogs," says Green. "I guess that in the last 10 years anywhere from 5,000 to 8,000 dogs have been used on as many as 4,000 ranches and farms throughout the United States and Canada.

"When I began studying and raising guard dogs in 1978, there were probably no more than a thousand in the entire country," says Green.

Although requests for trained dogs far outnumber the supply, Green's main purpose has been to determine whether the dogs really protect sheep and to find ways to enhance their effectiveness.

"It's critical that the dogs be no more than 8 weeks old when they're introduced to the sheep," says Green. "Dogs form their social and emotional bonds when they're between the ages of 8 and 12 weeks old. Unless they're with the sheep at this time, they'll bond with people and never make good guard dogs."

"More than 80 percent of the ranchers surveyed indicated that the dogs saved sheep and were worth their initial cost of about $500, plus the dollar or two a day it takes to maintain them."

Jeffery Green, wildlife biologist, Dubois, Idaho

He thinks 2 or 3 dogs can adequately protect 1,000 ewes and their lambs. "Increasing the number of dogs per flock may add more protection, but may also cause friction among the dogs," he says.

When mature, the dogs usually weigh about 100 pounds (give or take 20 pounds), are white, floppy-eared, with long tails.

"Normally, guard dogs are not aggressive," says Green. "It seems to be their size that intimidates small predators like coyotes."

Guard dogs are sometimes needed to protect other animals besides sheep. Sue Rolfing of Columbia Falls, Montana, says her Great Pyrenees, Hanna, eagerly protects everything on the farm, especially the llamas. She and her husband Steve own the Great Northern Llama Company—a 15-acre farm with about 50 or 60 llamas, which they breed and use as pack animals for trips into nearby Glacier National Park.

Some of the comments Green received on the questionnaire included compelling illustrations of the dogs' fierce dedication.

Ira Perkins, of Bynum, Montana, reports that he has seen his Akbash, Karla, aggressively confront black bears and even grizzly bears at times.

"She'll stand almost nose to nose with a bear and stare at it," he says. "If the bear tries to get her, she dodges just out of its reach.

"Eventually, Karla works the bear away from the flock and puts it on the run. She then returns to the flock."

Wyoming sheep rancher Dan Tracy says that 3 guard dogs have cut his yearly losses to coyotes down to 10 or 12 sheep compared to as many as 450 before.

Tracy ranches about 2,200 head in the Rocky Mountain foothills between Laramie and Cheyenne, Wyoming.—By **Howard Sherman,** ARS.

Jeffrey Green is at the U.S. Sheep Experiment Station, Dubois, ID 83423 (208) 374-5306. ◆

Superscales Help Growers Save Water

Huge underground scales will tell scientists exactly how much water cotton, tomatoes, cantaloupes, peaches, and grapes really need.

The devices, known as lysimeters, are at work near Fresno, California. Two of the four lysimeters are among the world's largest and most sensitive, capable of detecting weight changes as slight as the settling of morning dew. Each supports more than 25 tons of soil atop an underground truck scale.

Today, precision in irrigation is vital because it saves water, says soil scientist Claude J. Phené at the Water Management Research Laboratory.

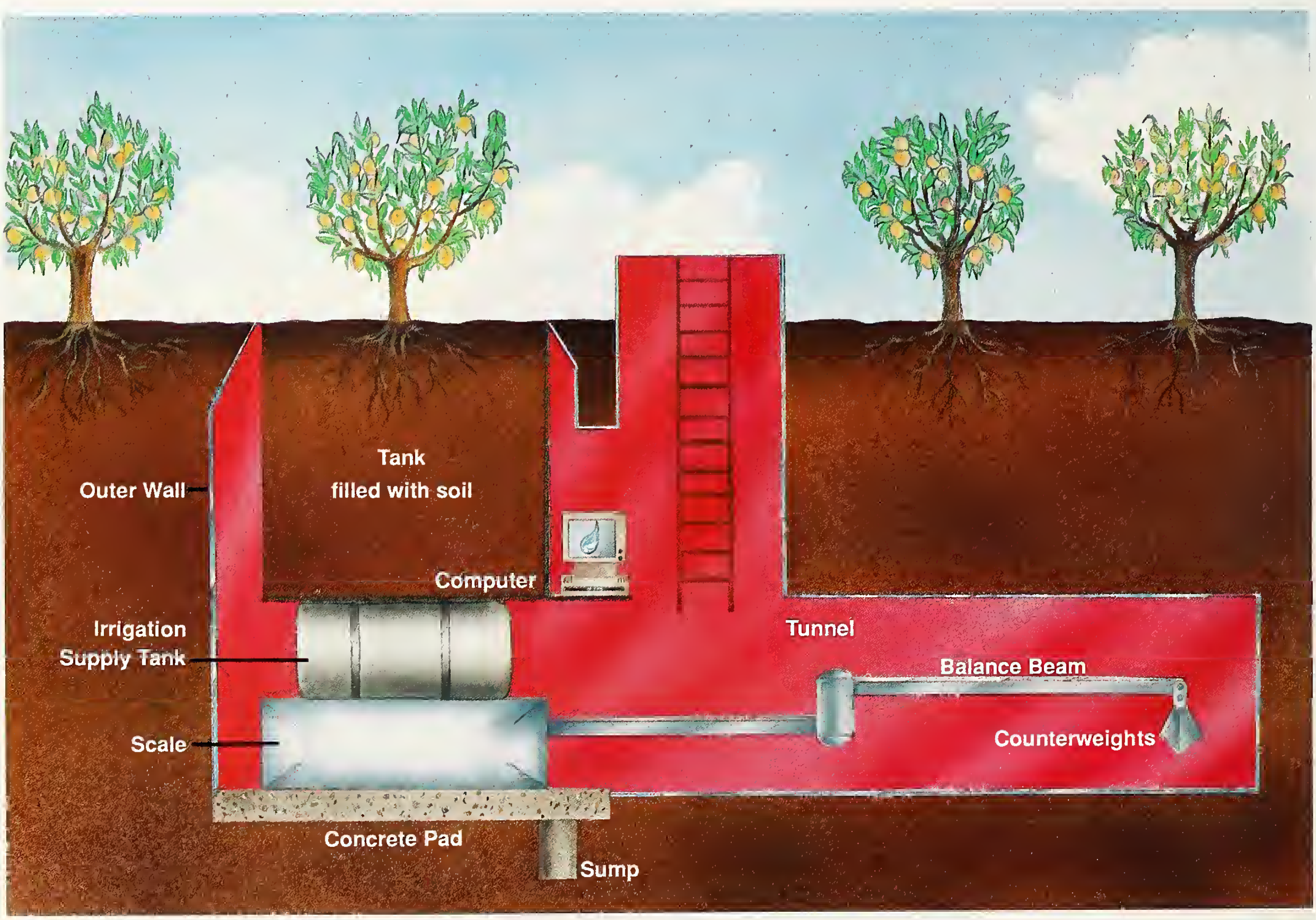
Even though high-quality water is cheap and plentiful in much of the United States right now, that water will cost more and be harder to get in the future, as competition heats up between farmer and city dweller, says Phené.

There's another major incentive for giving plants exactly the right amount of water at the time they need it most: Precision irrigation minimizes possible pollution from fertilizer being carried past the root zone. And it reduces the amount of excess irrigation water that moves through the soil into the underground water supply, bringing with it a troublesome load of salts.

The Fresno laboratory's giant lysimeters lie in research plots in California's San Joaquin Valley, the world's most productive agricultural region. But data that reveal how much water crops planted there use every day should be valuable to growers in other states, as well, including those in Oregon, Washington, Nevada, Arizona, and New Mexico.

"Like California, those states generally have very little rainfall in the summer," says Phené, "and we can make adjustments for differences in winter weather."

The lysimeters are essentially four large underground steel boxes filled



Peach orchard lysimeter at Kearney Agricultural Center, Parlier, CA.

with dirt. Two are about 6 feet wide, 6 feet long, and 7 feet deep; two larger ones measure 6 feet wide, 12 feet long, and 6 feet deep.

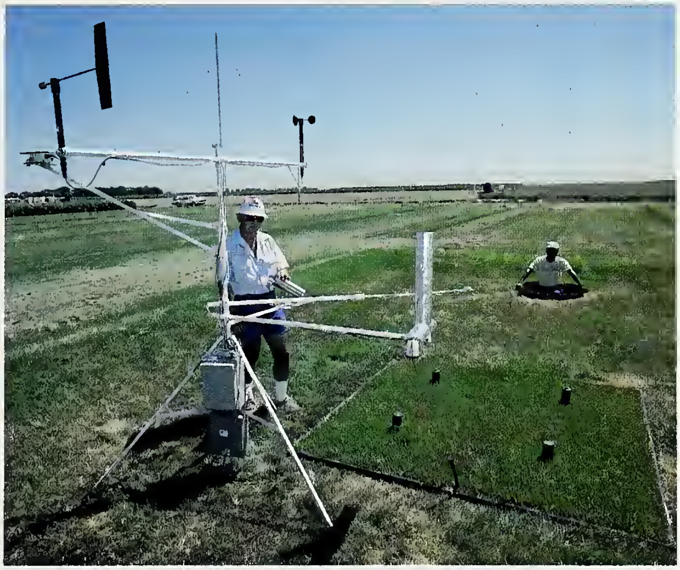
Although lysimeters aren't new, the Fresno laboratory's largest (along with similar devices at ARS' Conservation and Production Research Laboratory in Bushland, Texas) are unusual because of their size.

Young peach trees and young Thompson seedless grapevines are now growing on the bigger of the lysimeters Phené uses. But if you were in the surrounding experimental orchard and vineyard, you'd probably have a hard time finding the devices. The best clue to their whereabouts is a corrugated pipe sticking about two feet out of the ground. The pipe encloses a narrow ladder that leads down to a small chamber.

This hideaway houses the exposed underside of the scale and devices that automatically log data fed around the clock from electronic sensors and probes. Those instruments measure weather, the soil's moisture, and weight changes that occur as water is added, then evaporated from soil or by plants.

These and other measurements are automatically transmitted to computers at Phené's laboratory.

He's using the figures to develop new and improved mathematical formulas for irrigating crops. Growers who have personal computers may someday rely on these formulas and weather forecasts to find out how much water their crops used and how much water they will need that day—in amounts as precise as 1/25 inch. Right now, growers often use numbers, known as evapotranspiration coefficients, to decide how much water to apply.


CON KEYES

As engineering student Cliff Ma emerges from the underground office, soil scientist Claude Phené checks the weather station above a grass-covered lysimeter near Fresno, California. (K-3233-1)

The coefficients are essentially a measure of how much more—or less—water their crop would need as compared to closely clipped, well-watered grass grown nearby.

What's wrong with the coefficients? Phené explains that they are best for furrow irrigation, in which water is infrequently sent down long channels between the raised beds where the plants are growing. The numbers aren't precise enough for the increasingly popular drip irrigation systems. In those, water is applied far more frequently with narrow (usually less than 1-inch-diameter) tubing that delivers it a drop at a time to waiting plants.

"Growers who use drip irrigation could easily apply too little or too much water by relying on the furrow irrigation coefficients," Phené says. "To raise cotton or tomatoes in the San Joaquin Valley, growers typically apply 36 inches of water. But we've found that both crops really need only about 24 to 28 inches of water, maximum, applied with drip systems."

The potential savings in water that crops don't need, and can't use, adds up. "In cotton alone, we could probably save about 1- to 1-1/2-million acre-feet of water a year in California and still get the same yield, or better," he says. That savings is enough to meet the water needs of all of the households in the Los Angeles area for 1 year.

Preliminary results from his experiments with cantaloupes indicate that this crop, too, can be irrigated—with either drip or furrow irrigation—using aboutt 30 percent less water than is typically applied.

Figures for the peach trees and grapevines growing on lysimeters at the University of California's Kearney Agricultural Center aren't ready yet because the plants are only 3 years old. Since there's so little information on water needs of young trees and vines, those new numbers will be especially welcome.—By **Marcia Wood,** ARS.

Claude J. Phené is at the USDA-ARS Water Management Research Laboratory, 2021 South Peach Ave., Fresno, CA 93727 (209) 453-3100. ◆

Adapt-a-Plant

The traditions of farming have usually called for deciding on a crop variety and pushing and pulling on the environment until it grows that variety.

But in the past few years, an increasing number of scientists have been approaching the problem of growing crops at the extremes of climate and soil type from the other side of the problem.

Rather than figuring out what has to be added to the soil or which way to shift the planting date, they have been adapting the crops—breeding them to naturally suit the circumstances instead of manipulating their environment.

"It used to be to plant a crop that was not well-adapted to an area, be it grass for the lawn, tomatoes in the garden, or wheat in the field, it was nothing to monkey with the conditions—fertilizing, liming, pouring in additives; or irrigating—until you created the needed growing environment," says Charles D. Foy, a soil scientist with ARS' Beltsville Agricultural Research Center in Beltsville, Maryland, who has wholeheartedly adopted the adapt-a-plant approach.

Adapting plants instead of environments can be ecologically cleaner and economically more efficient, Foy says. A crop that makes better use of nutrients, for example, means less fertilizer need be applied. That creates less chance of fertilizer leaching to pollute groundwater.

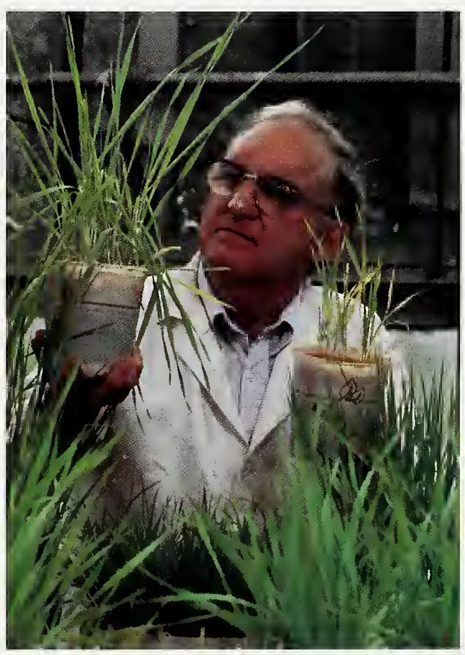
"Why spend hundreds of dollars adding lime to neutralize an acid soil when we can breed a variety that will do well in the natural acid soil?" says Foy.

And in many Third World countries, Foy continues, it may never be practical to bring in enough limestone, add enough fertilizer, or irrigate with enough water to grow some existing high-yielding varieties of crops.

"Keep in mind, 40 percent of the cultivated farmland and up to 70 percent of the potentially arable land in the world lies in tropical forests and grasslands that have acid, highly weathered soils, according to the estimates made by the National Academy of Sciences."

"That doesn't mean those areas have to give up the hope of planting high-yielding varieties," Foy says. "The idea is to add to the plant whatever adaptive traits you need without giving up yield, superior quality, or insect and disease resistance."

"There's also a human nutrition angle to this breeding to suit the environment," Foy says.



KEITH WELLER

Soil scientist Charles Foy compares barley plants grown in different levels of soil acidity. (K3212-1)

One reason strains have different tolerances to conditions is that they vary in the amount of mineral elements they take up from the soil. So it's possible to breed a variety to take up the level of a specific mineral that we want in our diet."

Acid Indigestion

In Ohio, high aluminum concentrations in acid soil have prevented farmers from growing high-yielding wheats that cannot tolerate aluminum, unless they invest in large amounts of lime to alter the soil. And the problem of acid soil is spreading.

High-aluminum acid soils are now being found in wheat-growing areas of the southern Great Plains, in eastern Kansas and Oklahoma in particular, and in the Northwest. Such soils could eventually cut into wheat yields. This condition is likely a result of applying high levels of nitrogen fertilizer, which acidifies the soil.

With that growing problem in mind, Foy collaborated with H.N. Lafever from an Ohio State University research center in Wooster, Ohio, to find an aluminum-tolerant wheat variety. In 1986, Lafever released Cardinal, a soft red variety of winter wheat that has excellent yield and strong straw. It can be depended on to produce well in acid soils with high levels of aluminum and can match high-yielding varieties in good soils.

Some acid-tolerant wheats actually change their root environment to suit themselves. They raise the pH of their root zone, thus reducing the availability of potentially toxic aluminum, instead of waiting for the farmer to make changes with additives.

Research geneticist Thomas Carter, Jr., inspects elongated root systems of Japanese soybean plants. These plants wilt slowly during extreme drought and tolerate more aluminum than most other varieties of soybeans. (K-3213-1)

In addition, plants may modify the chemistry of a micro-thin layer of soil around their roots. The roots in this case may release organic acids that tie up and detoxify the harmful aluminum, Foy says.

Foy also worked on the development of a strain of limpograss that not only has an exceptional tolerance for aluminum and acid soils, but is also cold tolerant. This grass has excellent potential for rehabilitating and preventing erosion of acid, mine-spoil soil at higher elevations, he says.

At the U.S. Regional Pasture Research Laboratory in University Park, Pennsylvania, Gerald A. Jung has found varieties of switchgrass and big bluestem, warm-season forages usually grown in the West, which have extraordinary tolerance to strongly acid soils.

These grasses, which tolerate low levels of soil nutrients and high levels of aluminum, are being used to reclaim mine-spoil soil in Pennsylvania and West Virginia in areas where the terrain is too steep to lime.

Even homeowners trying to grow lush lawns with the ever-popular bluegrass have benefited from the adapt-a-plant approach. Bluegrass usually needs a more neutral (less acid) soil to grow well, requiring homeowners to lug home sacks of limestone and manhandle spreaders across their lawns to promote a glowing green lawn.

But Foy and agronomist James J. Murray, working in the ARS Germplasm Quality and Enhancement Laboratory in Beltsville, searched for and found a bluegrass that will grow well in acid Virginia soil. The acid-tolerant bluegrass has already replaced an acid-sensitive cultivar in some common grass seed mixes.

Salty Crops

Out in the arid West and Southwest, high levels of salt in the soil plague millions of acres of land, limiting farming and crop choices. Reclaiming saline soils, usually by pouring on large amounts of irrigation water and gypsum, can cost more than $750 per acre, when it can be done at all.

In hopes of getting around the expense and limitations, scientists at the agency's U.S. Salinity Laboratory in Riverside, California, are studying tomatoes to discover why some species can flourish in a salty environment.

"Wild ancestors of today's commercial tomatoes take in salt along with water. But they concentrate the salt in older leaves, where it won't affect the plant's growth," says ARS geneticist Michael C. Shannon, who works at the Riverside laboratory.

"If we can develop salt-tolerant crop varieties, we would automatically expand the acreage where they can be grown economically," Shannon says.

For Lands Without Water

In Tucson, Arizona, ARS geneticist Robert T. Ramage, Jr., has been breeding a barley that can prosper with restricted water.

"Water is the limiting factor to expansion of agricultural production in many parts of the world. There

Seco, a drought-tolerant variety of barley developed by geneticist Robert Ramage, Jr.

aren't many areas left where irrigation projects can be easily developed," says Ramage.

Ramage's barley, called Seco—which means "dry" in Spanish—puts roots deep in the soil early in the season, and it matures early. These characteristics allow it to produce better than other barleys on much less water.

A much deeper root system is also one of two characteristics that may make an exotic Japanese soybean a parent of a soybean variety that could be grown without as much irrigation as is common now. Research geneticist Thomas E. Carter, Jr., has found that under extreme drought conditions, this Japanese soybean will survive better than most varieties currently grown in the Southeast.

In addition to the deeper roots, the variety uses an unusual system called osmotic adjustment to accumulate salts, sugars, and organic acids in the leaves. This in turn promotes water retention and retards wilting, according to Carter.

"Our next step is to pinpoint what chemical changes are directly due to osmotic adjustment and are most important to the plant's drought tolerance," he says. "Once we know that, we'll work on transferring those abilities to the high-yielding commercially desirable varieties."

Iron-Poor Soil

Unlike acid soils where too much of a metal such as aluminum causes problems, in alkaline soils some minerals, particularly iron, are often tied up and unavailable to plants. This makes the soil infertile.

"And for example, there is no economically sound way other than genetic manipulation to make iron-deficient soils palatable to soybeans," Foy says. "As the area in which soybeans are grown has become larger, such soils have become more of a problem."

Rufus L. Chaney, an agronomist at the ARS Soil-Microbial Systems Laboratory in Beltsville, has developed cost-effective methods of screening soybeans and other plants to turn up varieties that resist iron chlorosis on alkaline soil.

"Now plant breeders, both commercial and university based, are routinely publishing iron chlorosis data about new varieties," Chaney says. "Farmers demanded such information about soybeans, and we could really use a similar index for other crops."

With screening tests to provide data during the development of new varieties, breeders have discovered that yield and iron chlorosis resistance are independent traits and it is possible to breed to enhance one trait while not affecting the other, Chaney says.—By **J. Kim Kaplan,** ARS.

Charles D. Foy is at the USDA-ARS Climate Stress Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-4522. Michael C. Shannon is at the U.S. Salinity Research Laboratory, 4500 Glenwood Drive, Riverside, CA 92501 (714) 369-3834. Robert T. Ramage, Jr., is at the USDA-ARS Barley Genetics and Breeding Research Laboratory, 2000 East Allen Rd., Tucson, AZ 85719 (602) 621-7958. James J. Murray is at the USDA-ARS Germplasm Quality and Enhancement Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-3655. Gerald A. Jung is at the U.S. Regional Pasture Research Laboratory, Curtin Rd., University Park, PA 16802 (814) 863-0948. Rufus Chaney is at the USDA-ARS Soil-Microbial Systems Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-3324. Thomas E. Carter is at the USDA-ARS Soybean and Nitrogen Fixation Research Laboratory at North Carolina State University, P.O. Box 7631, Raleigh, NC (919) 737-3171. ◆

Streambank Plants Vital to Water Quality

Some studies suggest that up to 80 percent of streamside vegetation in northern California mountain meadows may have been lost as a direct result of human activities. Livestock grazing, logging, mining, road building, and recreational uses have all contributed to the destruction of the streambank ecology.

And without the plants needed to stabilize them, soil eroding from streambanks sends sediment down to clog drinking water reservoirs, reduce fish populations, and block hydroelectric dams, one of the region's main sources of power.

"Before we can reduce this type of damage, we have to know more about the native plants and how they grow," says ARS range scientist Tony J. Svejcar, who is based in Reno, Nevada.

He is part of a USDA/state task force aimed at stopping sedimentation and eventual destruction of this delicate environment along the banks of California's Feather River and its tributaries.

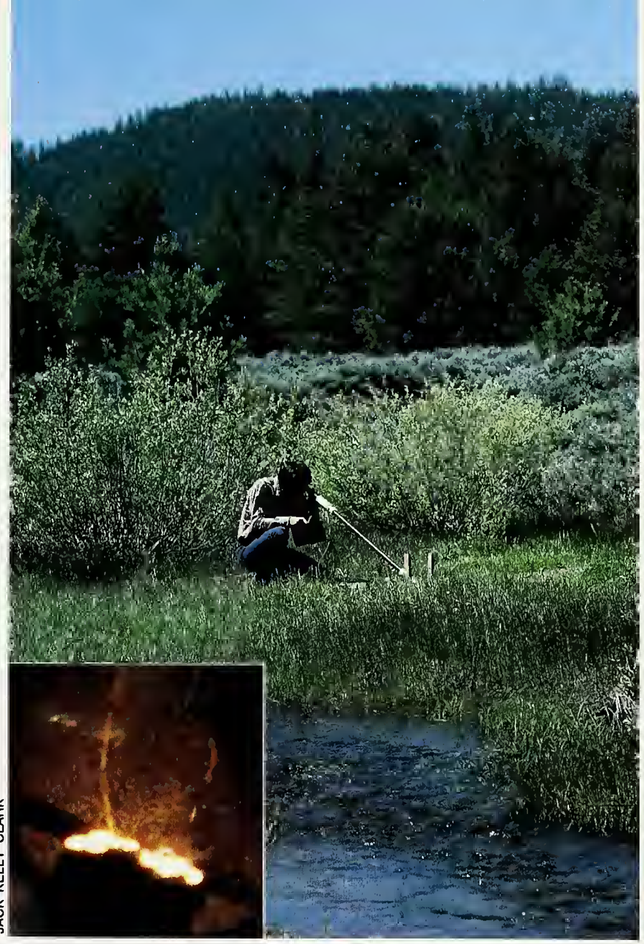
Svejcar has been studying the effect of seasonal climate changes on the root growth, photosynthesis, and water use of willows and grasses along three tributaries of the Feather.

He says, "besides providing healthy habitats for fish and forage production, these plants—in particular, their roots—are critically important for controlling erosion and sedimentation, especially in the spring when melting snows cause heavy streamflow."

Svejcar uses a high-tech, belowground periscope to study root growth. Although the use of the periscope, also known as a rhizotron, is not new, this is the first time scientists have applied this technology to wetland plants.

Optical fibers in the scope light its sidewalls, enabling Svejcar to determine exactly when roots make their most growth. "First, we place a Pyrex glass tube into the ground at a 30-degree angle," he says. "Then, at various times, the periscope is inserted into the tubes so we can observe the number of roots that touch the glass tube at different depths."

Before the fiber-optic scope was developed, it was necessary to construct deep, glassed-in trenches to observe root growth.



JACK KELLY CLARK

On Freeman Creek in California's High Sierras, range scientist Tony Svejcar peers at the roots of streamside plants. (K-3197-15) Below ground (inset), roots are illuminated by optical fibers. (K-3197-5)

Svejcar also uses a portable photosynthesis meter to measure the amount of carbon taken in and moisture used by the plant. "It's another way to find out when maximum growth is taking place. In order to give plants the best opportunity to grow, it's critical that grazing be controlled at these times."

Although streamside vegetation makes up only 5 to 10 percent of these meadowlands, it provides about 90 percent of the usable forage for northern California livestock producers.

Svejcar and USDA Forest Service range conservationist Scott Conroy of the Plumas National Forest are evaluating different techniques for replanting willows along streambanks and seeding them with such grasses as reed canarygrass, wheatgrass, meadow foxtail, and redtop.

Svejcar is also working with livestock grazing researcher Mark Judkins, University of Nevada, Reno, to evaluate the impact of different grazing patterns on plants livestock select to eat. Their purpose: To see how early-season versus late-season grazing affects the growth of these plants and water quality and how many cattle can safely graze a given area.—By **Howard Sherman,** ARS.

Tony J. Svejcar is in USDA-ARS Landscape Ecology of Rangelands Research, 920 Valley Rd., Reno, NV 89512 (702) 784-6057. ◆

Nunas: A Nutritious Snack Food

Colorful beans that pop after cooking a few minutes in oil, hot air, or the microwave may someday show up on supermarket shelves, next to the popcorn.

Like popcorn, the beans, or nunas (pronounced "noon-yahs"), burst and expand when rapidly heated. Unlike popcorn, nunas do not radically change shape when they pop. They merely puff up slightly and split in half, yielding a tasty, high-protein snack.

These beans are currently grown at high elevations in the Andes Mountains of Peru, Bolivia, and Ecuador. They are not available in the United States yet.

"If we could grow the beans, U.S. consumers would be sure to like their nutlike flavor and high fiber content, important in reducing serum cholesterol," says plant physiologist Stephen C. Spaeth, Pullman, Washington.

"But first, we need to know more about how popping takes place before nuna plants can be grown outside their traditional areas," says Spaeth.

"We also need to breed varieties that will flourish under our own growing conditions," says Spaeth's colleague, plant pathologist Matt J. Silbernagel in Prosser, Washington.

Because ARS has access to the costly equipment needed to study the beans' complex internal structure, Spaeth and Silbernagel are lending a hand to scientists at CIAT (Centro Internacional de Agricultura Tropical) in Cali, Colombia, who would like to see the beans become a commercial crop there and around the world.

Spaeth believes "popbeans" could become a nutritious snack food crop for Pacific Northwest bean growers.

There's a major roadblock for U.S. growers to overcome, though, The beans will grow at lower elevations, but they refuse to pop.

"Pullman scientists have grown the popping types at lower elevations than those found in the Andes—but so far only in greenhouses," says Spaeth.

Nuna beans vary greatly in color from light red to dark purple and even black with white spots, somewhat like miniature speckled bird's eggs. They range from one-fourth to one-half inch around and in shape from round to elongated.

Nuna pods hang at knee height and higher from 6- to 9-foot climbing vines—much like pole beans common in backyard gardens throughout the United States. Each pod contains three to six beans.—By **Howard Sherman,** ARS.

Stephen C. Spaeth is in USDA-ARS, Grain Legume Genetics and Physiology Research, Room 215, Johnson Hall, Washington State University, Pullman, WA 99164-6421 (509) 335-9521. Matt J. Silbernagel is in USDA-ARS Vegetable and Forage Crops Production Research, Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, WA 99350 (509) 786-3454. ◆

JOHN KUCHARSKI

Colorful and tasty nuna beans will pop after a few minutes of cooking. Someday they may appear on supermarket shelves as a nutritious snack food. (K-3245-1)

NIRS Detection Saves Labor

Dairy farmers can't afford to miss the signals from a cow that it's biologically ready to mate. To do so means periods of delayed lactation and increased costs to maintain non-producers.

The Dairy Herd Improvement Association estimates that cows that are bred late cost farmers 12 to 19 pounds of milk each day lactation is delayed or about $300 million each year.

The signals for estrus, which are sometimes too subtle for even an experienced livestock producer, require considerable labor to detect by the usual method—observation.

One answer to the problem may be on the horizon. A new technology using near infrared light and a small computer can reliably detect estrus from a cow's vaginal mucus, say Agricultural Research Service scientists at Logan, Utah.

Known as NIRS for near infrared reflectance spectroscopy, the technology is already widely used to give

nearly instantaneous protein readings for grain and forages. Other uses for the versatile detectors include measuring fat in meat, sweetness in melons, tea quality, and milk composition.

ARS animal scientist David H. Clark says, "We're seeing big differences in the near infrared wavelengths from animals that are ready to breed and those that are not.

"But," he says, "even though it's easy to see these differences in the laboratory, the technology needs refining before dairy farmers can use it. It takes too much time and labor to collect the mucus samples.

"We need some sort of labor saving device such as a portable remote sensor or fiber optic probe (a type of handheld wand) that a farmer could use to quickly sample mucus as cows are being milked or fed. This would relieve farmers of hours of tedious cow watching—looking for signs of estrus."

He believes such a tool could be devised by instrument companies in the near future.

An NIRS instrument, using a fiber optic probe to measure human body fat, was developed by ARS engineer Karl H. Norris and chemist Joan M. Conway.—By **Howard Sherman,** ARS.

David H. Clark is at USDA-ARS, Dairy Management Research, UMC 48, Agricultural Science Building, Logan, UT 84322-4863 (801) 750-3297. ◆

Eat-All Melon

Horticulturist Perry E. Nugent is envisioning a snack melon that would be as handy to eat as an apple—or even handier, since it wouldn't have a core or seeds to dispose of.

"I call it the eat-all melon and it would be perfect for selling in vending machines as a snack food," he says.

Ultimately, his goal is to breed an egg- or plum-size melon with an edible rind. The melon would ideally be seedless or have an edible seed cavity and a shelf life about as long as an apple's or orange's—and, of course, with the delicate, fresh flavor of a melon.

Nugent, of ARS' Vegetable Lab in Charleston, South Carolina, has already succeeded in breeding two disease-resistant canteloupe-like melons with thin, edible rinds with a smooth skin and firm flesh like an apple's. The most attractive of the two has a bright yellow rind and pink flesh, although the fruit is still more family size than snack. The other has high yields with 6-15 grapefruit-size melons per plant, but the flesh is an unattractive off-white, although sweet.

Nugent is confident he can bring the size of the fruit down to single serving. And he would like to improve on the melon's crack and disease resistance.

"We could release these lines as improved germplasm for commercial breeders to use to develop their own melons, but I think, because of the uniqueness of these melons, we are going to go ahead and finish creating a variety. It will almost certainly be a hybrid of some type," he says.

"The hard part will be adding seedlessness. After all, they've spent 50 years or so working on a seedless watermelon," Nugent says. "We hope the technology used in the watermelon development will also work for cantaloupes."

So far, crosses have resulted in sterile seed instead of seed that produces plants with seedless fruit as happens in watermelons.

He would also like to breed in shelf life that would make them last at least a week in a vending machine. "That's a long time to expect today's commercial melons to last," Nugent says. "But it would mean not only a new, healthy snack to sell in vending machines and supermarkets, but a melon you could truck anywhere to market."

To get the genes he needs to create the eat-all melon, Nugent turned back to wild melon varieties he's found in a USDA plant germplasm collection in Ames, Iowa.

"I started with melons the size of cherry tomatoes and then crossed them with more commercial types," he says. The crosses produce melons with unique characteristics. One fruit Nugent recently harvested in his greenhouse was only an inch and a half in diameter, weighed about an ounce, and had a pleasing yellow and cream rind. Unfortunately, it also had a very large seed cavity.

The real test, of course, will be the melon's flavor and vitamin content. Nugent is collaborating with Doyle Smittle, professor of horticulture at the University of Georgia, who will arrange the necessary taste testing and quality evaluations as well as also make breeding crosses toward the eat-all melon.

"Melons come in a tremendous range of flavors from fruit punch to lemon to apple," Smittle says. "Right now, I want to make as many crosses as I can, to get as many different colors and flavors as possible. The perfect flavor and color combination may turn out to be a matter of good fortune and chance."

Smittle is also trying to biochemically pinpoint the compounds responsible for specific flavors in melon. "That way we can check for flavor objectively and with a small sample during the breeding process. But in the end, we'll depend on a taste panel to tell us when a melon tastes good."

Taste tests might have begun last year, but deer ate the experimental crop of thin-skinned melons in Georgia and raccoons raided the crop in Charleston.

Melon lovers will have to be patient. Although Smittle has succeeded in breeding a melon only 2 inches in diameter with a thin edible rind and an extremely small seed cavity, neither he nor Nugent expects to have a variety to release any earlier than 1991 or 1992.—By **J. Kim Kaplan,** ARS.

Perry E. Nugent is with the U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29414 (803) 556-0840. ◆

Underground Microbes Counter Chemicals

The unseen armies of microorganisms maneuvering beneath the soil's surface may have some surprise recruits.

Soil microorganisms play a major role in breaking down or degrading agricultural chemicals. The microorganisms' enzymes nibble away at herbicide molecules, typically changing them to a less harmful substance.

As chemicals wend their way closer to underground water supplies, however, this activity seems to slow. Scientists have attributed this to smaller numbers of microorganisms deeper in the soil.

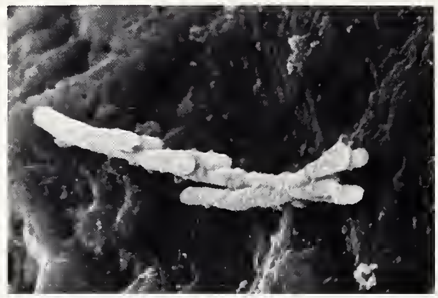
Soil microbiologist Thomas B. Moorman and soil scientist Sidney S. Harper have another idea: that the deeper microorganisms may actually be different from their upstairs cousins.

"There are differences in numbers," says Moorman, who works with Harper at ARS' Southern Weed Science Laboratory at Stoneville, Mississippi. "But we suspect the microorganisms deeper in the soil are less efficient at breaking down herbicides."

Getting to know the deeper microorganisms is important because the information can be useful in assessing the likelihood of herbicide contamination of underground water supplies, says Harper.

"We want to find out what's going to happen to a herbicide once it gets to the groundwater," she says. "Will it be degraded by these microorganisms, or just stay there?"

Moorman and Harper are testing microorganisms in laboratory experiments using Dundee silt loam, typical of the Mississippi Delta, and Eustis loamy sand, typical of the Coastal Plains of Georgia and Florida.


REX PAUL

Pesticide-degrading bacteria on the surface of a grain of sand at Plains, Georgia. Magnified about 3,200 times. (88BW1165)

The scientists mixed Eustis soil from eight depths with the herbicide alachlor at about 1 part per million. They checked the mixtures seven times, at intervals ranging from 0 to 161 days, to see how much herbicide the microorganisms had eliminated.

"The half-life is the amount of time it takes for half of the herbicide to break down," explains Moorman. "At the surface, alachlor's half-life was about 23 days. At 50 feet, the half-life was about 380 days."

The chemical metribuzin degraded in Dundee loam about three times faster in the first 2 inches than in the next 2 inches down, Harper says.

Moorman and Harper will study 120 randomly selected microorganisms from Eustis soil for physical differences and ability to break down chemicals.

They will also study the impact of tillage practices and nutrients such as nitrogen on the microorganisms' efficiency.—By **Sandy Miller Hays**, ARS.

Thomas B. Moorman and Sidney S. Harper are at the USDA-ARS Herbicide Interactions in Plants and Soils Unit, Southern Weed Science Laboratory, P.O. Box 350, Stoneville, MS 38776 (601) 686-2311. ◆

Grasses Control Excess Fertilizer

Grasses are about four times as efficient as legumes at recycling excess nitrogen fertilizer.

Excess nitrate from fertilizers can leach down to groundwater and become a pollutant. One way farmers try to avoid this problem is by planting a crop in late fall that will use up any nitrate not used by the last crop.

The question then becomes: Which crops are best to use as winter cover crops?

For a clear—if regional—answer, Agricultural Research Service scientists used an ammonium nitrate fertilizer that was tagged with N-15, an isotopic form of nitrogen that is found only in minute quantities in nature or in commercial fertilizer.

At a University of Maryland research farm on Maryland's Eastern Shore, ARS soil scientist J. J. Meisinger and graduate student Paul Shipley applied the tagged fertilizer to corn for 2 years.

Each fall they measured the residual tagged nitrogen in the soil to 2 feet and planted cover crops of cereal rye, ryegrass, hairy vetch, and crimson clover. The next spring the cover crops were harvested, ground, and analyzed for N-15. Any N-15 found could come only from the previous corn fertilizer.

Considering only the aboveground nitrogen uptake, they found cereal rye and ryegrass were the best winter cover crops by far. Each took in about 40 percent of the fall residual nitrate. The hairy vetch and crimson clover legumes each took up only about 10 percent.—By **Don Comis,** ARS.

Jack Meisinger is at the USDA-ARS Environmental Chemistry Laboratory, Room 5, Bldg. 008, BARC-West, Beltsville, MD 20705 (301) 344-3276. ◆

Patents

A Mover and a Shaker

A new invention that mechanically harvests small fruits may reduce a grower's picking costs and improve the quality of the harvest.

This device could also give the processing industry access to the new, thornless blackberries that have been an instant success in the fresh markets.

"Most fruit for fresh-market consumption is now hand-picked," says ARS engineer Donald L. Peterson. "Small-fruit growers face multiple problems in harvesting their crops. Not only is hand labor expensive, but there is no guarantee that qualified laborers will be available when they're critically needed."

To remedy these problems, Peterson, working at the Appalachian Fruit Research Station in Kearneysville, West Virginia, designed a new spiked-drum shaker. The device, attached to a mechanical harvester, shakes the vines just enough to remove the fruit with minimum damage to both fruit and vines.

As the harvester moves between the rows, the drum gently shakes each cane, relieving it of ripened fruit.

The device consists of a stationary frame and oscillating arms that support rod panels. Several flexible nylon spikes, radially spaced at equal angles, extend from the rod panels. In motion, the spikes resemble small Ferris wheels minus the bucket seats. It's the steady swinging of the spikes that seems to be the secret of the shaker's success.

"We can easily position the shaker for most types of trellises that growers use: V-shaped, T-shaped, or conventional vertical-trellis shape," he says. "It has fewer moving parts than other shakers and is effective because it delivers more uniform force and acceleration—ideal for harvesting blackberries."

Mechanical harvesting could help develop a new processing market. To increase harvest efficiency, Peterson is working with horticulturist Fumiomi Takeda to integrate improved growing practices with the ability to machine harvest.

Although this harvester was specifically designed for thornless blackberries, Peterson says he hopes to use it on other crops that grow on prickly vines, such as raspberries, or on blueberries and other small fruits.

ARS introduced the first thornless varieties, Smoothstem and Thornfree, in 1966.—By **Doris Sanchez,** ARS.

For technical information about this patent, contact Donald L. Peterson, USDA-ARS, Appalachian Fruit Research Station, Rte. 2, Box 45, Kearneysville, WV 25430 (304) 725-3451. Patent application serial No. 07/229,877, "Shaking Mechanism for Fruit Harvesting." ◆

BOB BJORK

Engineer David Peterson watches his spiked-drum shaker as it traverses a row of blackberry bushes at the Appalachian Fruit Research Station, Kearneysville, West Virginia. (K 2949-6)

Letters

*We invite letters from readers and, from time to time, will share them in this column.—**Ed.***

On Biocontrol: I was delighted with the March issue highlighting the 100th anniversary issue of biocontrols. The prophets of the Green Revolution , who focused their work on increasing yields of crops and livestock, have tended to be pessimistic about our capability to produce similar breakthroughs in the 1990's and beyond...

I do not see biocontrol as the next lone panacea to effective crop protection strategy, but it can certainly cut down substantially on the 30-50% field losses which occur in many less developed countries.

Green Revolutionaries also ought to pay more attention to postharvest losses and marketing. In the U.S. the farm gate price of food is hardly one-fourth the price consumers pay for it at retail.

Frank Meissner
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